1,500 Kilometers of Shoreline Resource Information: Glacier Bay's Coastal Resources Inventory and Mapping Program

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Abstract. Detailed field and data processing protocols were developed to describe a variety of coastal resource attributes in Glacier Bay to make them easily available in an information-rich, map-linked interactive database. The focus is on resources associated with the intertidal zone and the immediately adjacent nearshore environments. Recorded attributes include beach substrate type, slope, relative exposure, intertidal community characteristics, and the presence of special resource features, such as kelp beds and pinniped haulouts. During seven field seasons, over 1,500 kilometers of coastline were mapped; this translates to 6,000+ discrete shoreline segments, 21,000+ ground photos, and 300+ high resolution georeferenced aerial photos. The final map-based interactive database provides instant access to gigabytes of data with a few mouse clicks. A popular component is an "ethnoecological encyclopedia" linked to all the marine intertidal species and species groups recorded as part of the inventory. The entire product (interactive database, actual Glacier Bay data, and protocols) fits on a single DVD, and a map server version is in development for distribution via the internet.

Introduction

Ask resource decision-makers to name the single asset that most determines their ability to effectively manage resources, and many will initially mention funding or skilled personnel. Upon further reflection, however, most will agree that usually what they really lack is information. Often this is information of the most general kind: How many of what kinds of animals are out there? Are they increasing or decreasing? What is the condition of the habitat?

At Glacier Bay National Park and Preserve, this information is arguably most critical for the marine shoreline. The park's nearly 1,900 kilometers of coast comprise the continuous geographic strip that is one of its most productive and diverse habitats and is the focal point for human activity and thus potential impact. This coastal strip, from nearshore kelp beds and intertidal reefs, across the intertidal zone and into the adjacent terrestrial vegetation is the area for which managers need accurate and detailed resource information. Yet, ironically, this is an area of the park for which such information has been lacking.

From 1997-2003, the Alaska Coastal Resources Inventory and Mapping Program sought to address this need by providing coarse-scale descriptive information on coastal resources for the majority of the park's most valuable and most vulnerable shores. Our goals were (1) to develop detailed field and data processing protocols, (2) to gather relevant coastal information useful to a variety of users, and (3) to make the information maximally accessible.

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Methods

Methodology for mapping marine shoreline attributes are diverse, most of which have focused on either physical or biological coastal elements (Howes and others, 1994; Schoch and Dethier, 1996; Zacharias and others, 1999; Berry and others, 2001; NOAA, 2002). Our approach documented both physical and biological resources, combined relatively high information density with large-scale mapping (hundreds of km), and developed a unique electronic database that organizes and displays all the information in a single location.

To decide which coastal resource attributes to describe, we surveyed a wide variety of potential users in an attempt to anticipate the uses of these data. Our focus was on relevance and usability. Potential uses for the information were diverse and included the general areas of scientific research, long-term monitoring, response to human-caused disturbance, resource management planning, visitor enjoyment, and education. The mapping protocols were developed for application to relatively protected and complex marine shorelines typified within Glacier Bay proper.

From 1997-2003, field mapping was conducted by teams of two who walked the coast during low-tide "windows", dividing the shoreline into segments based on changes in surface substrate and slope. Segment boundaries were carefully delineated on enlargements of high-resolution coastal aerial photography. For each shoreline segment, teams described standardized resource attributes including intertidal community composition and vertical zonation, adjacent upland vegetation type, and the presence of a variety of special features including streams, tidepools, embedded interstadial wood, offshore kelp beds, intertidal reefs, sediment anaerobism, flotsam collection areas, seabird colonies, and pinniped haulouts. Several ground photographs were taken for each segment. After the tide windows closed, field mapping teams retraced their steps, using resource-grade Global

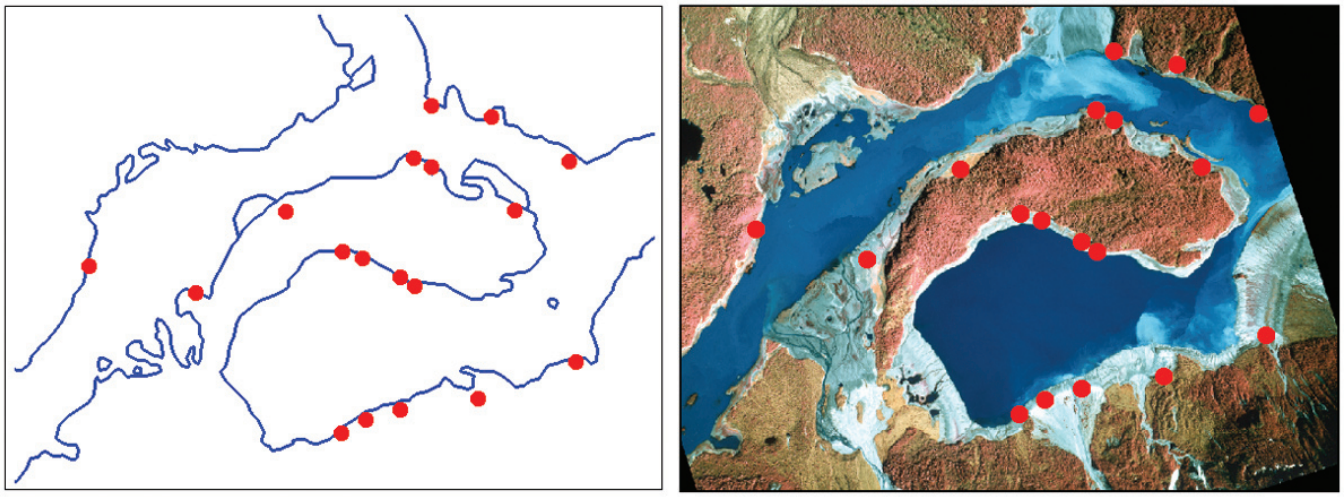

Figure 1. High-resolution coastal aerial imagery was georeferenced to geopoints located on the ground with Global Positioning System receivers. Spatial resolution/accuracy was ~2 m.

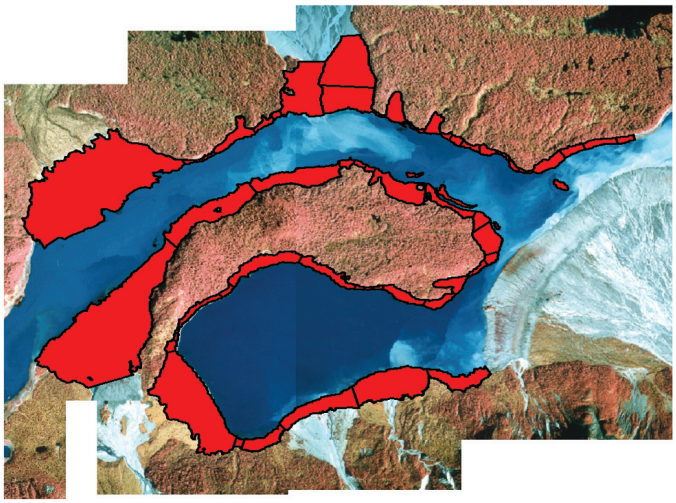

Figure 2. Shoreline segment polygons were hand-digitized onto the georeferenced aerial photography.

Positioning System receivers to capture precise (to within 2 m) locations of stable landmarks identifiable on the ground and on the aerial photos. These geopoint locations were later used to georeference the aerial imagery.

The aerial photographs were georeferenced to create the program's base map (figs. 1 and 2), and the segment polygons were digitized to link all the information together in a complex Microsoft Access© database that uses an interactive map powered by MapObjectsLite2©. An "ethnoecological encyclopedia" was created within the database with photos, observed distribution maps, and ecological and ethnological information pertaining to the 70-plus marine intertidal organisms searched for during the coastal biological inventory.

The field mapping and data processing protocols are documented in considerable detail, allowing the methods to be effectively transferred to others who may wish to adopt or modify our methods for application to shores elsewhere. Moreover, methods were intentionally designed to be maximally repeatable and as objective as possible in order to facilitate comparability of resulting data.

Results and Discussion

Over 1,500 km of the park's marine shoreline was mapped, which constituted some 6,000+ shoreline segments, 21,000+ ground photos, and 300+ high resolution georeferenced aerial photos. A large amount (on the order of one million records) of associated physical and biological resource data were linked to discrete segments.

All the information, together with the detailed field mapping and data processing protocols, resides together in the "one-stop shop" interactive database which is the tool designed to store and serve the data to end users. This database allows one to "walk the coast" and display for any segment its exact location, an aerial photo of that segment, ground photos showing what the beach actually looks like, and all coastal resource data associated with the segment. Knowledge of Microsoft Access© or even how to type is not necessary. The main user screen provides descriptions on how to manipulate the interactive map, and all of the data fields are hyperlinked to the field protocol that describes exactly how the data were collected.

The key to the database design is accessibility and ease of use. Its core functionality centers on the locator map, by which users can zoom in on mapped coastline anywhere in the park to select specific shoreline segments. The database is highly visual and intuitive, and can be utilized completely by mouse clicks. Ground photos can be enlarged and zoomed, and resource information is organized behind labeled file-folder-like tabs. The ethnoecological encyclopedia follows a similar format to the coastal data viewing form, with an interactive map and tabs for accessing additional information. Online help and hyperlinks to the protocols are available throughout. Pre-built data queries are available, and users have the option of performing their own custom queries using Microsoft Access©.

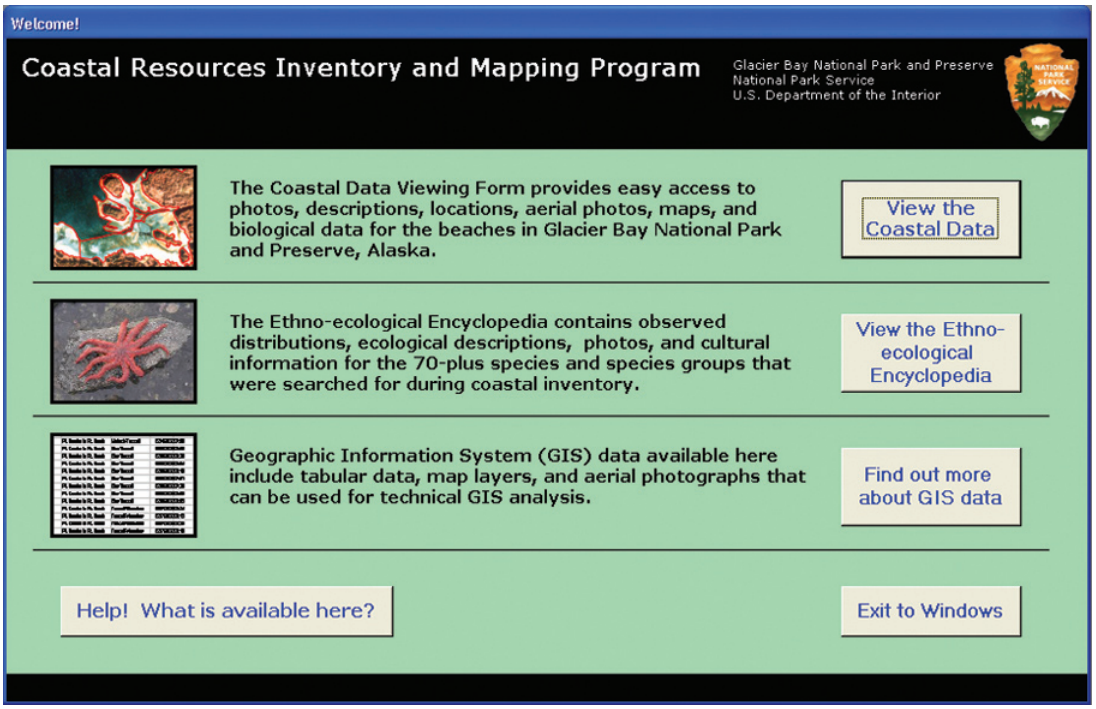

Figure 3. The opening screen of the Coastal Resources Inventory and Mapping Program database (in Microsoft Access©) is the entry portal for users.

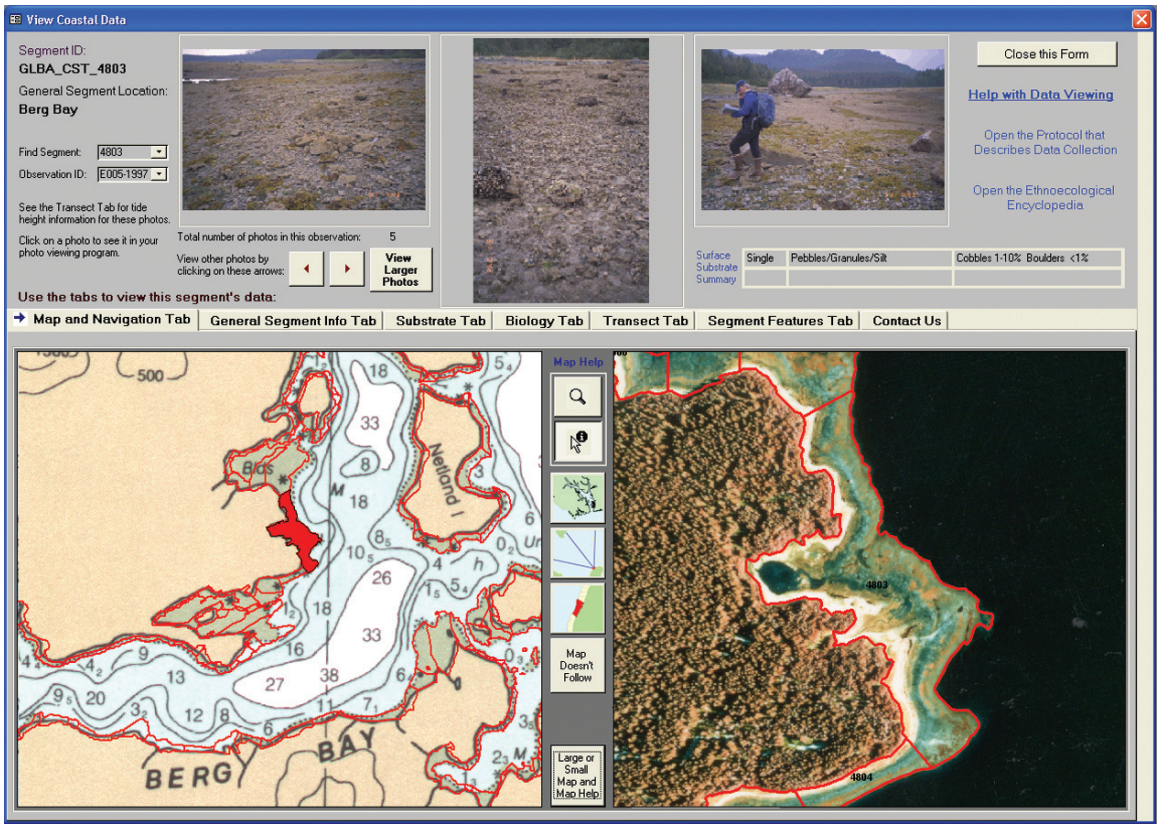

Figure 4. The coastal data viewing form's Map and Navigation Tab allows users to select a specific shoreline segment. It contains an interactive polygon map (lower left), an infrared aerial photo map (lower right), the selected polygon's ground photos (across the top), and clickable tabs (across the center) that provide access to the selected polygon's coastal resource data. The area above the tabs is always visible in this form; only the lower half of the screen changes as various data tabs are selected.

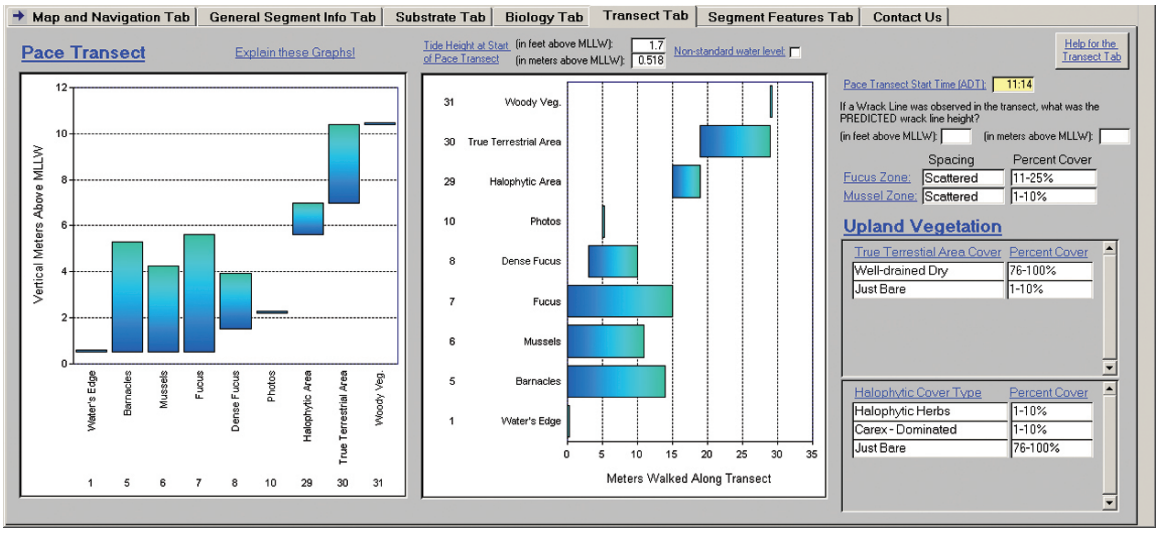

Figure 5. The coastal data viewing form's Transect Tab contains simple graphs summarizing complex vertical zonation data. Links to sections of the help document pertaining directly to this tab are present in the top right corner and above the left graph.

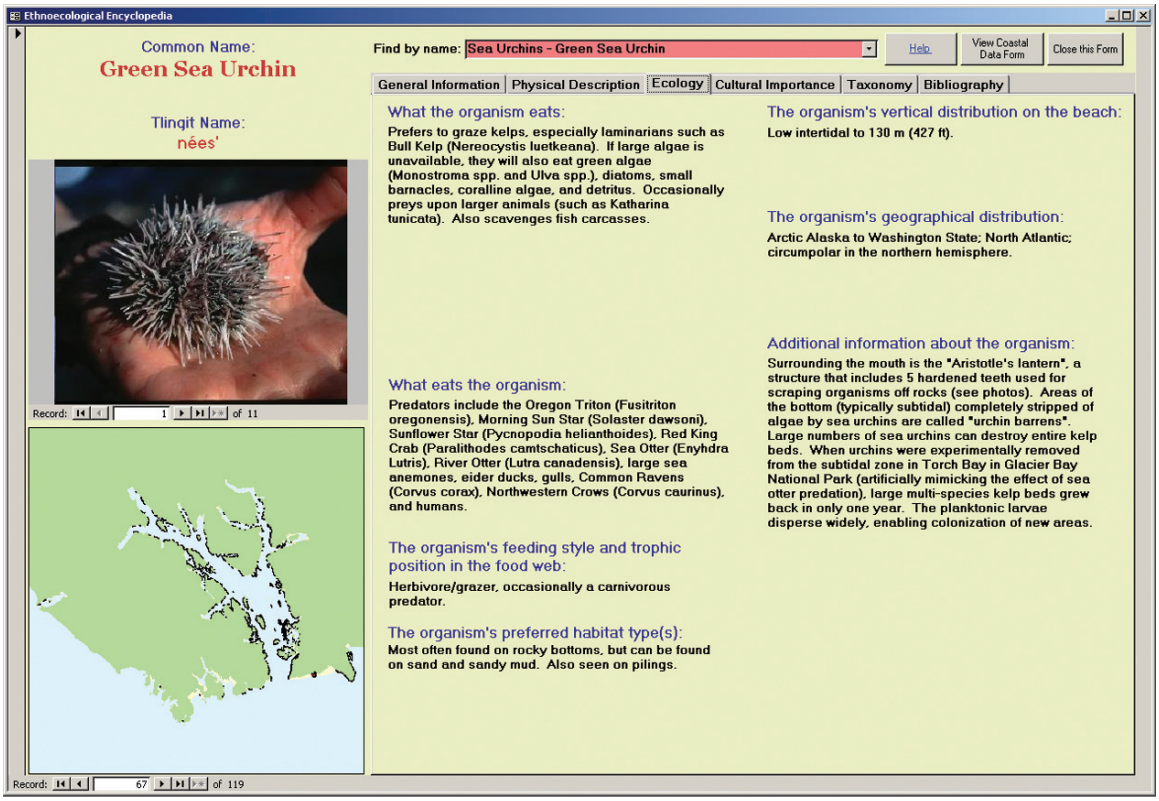

Figure 6. The ethnoecological encyclopedia contains detailed information about the 70-plus species or species groups searched for during the coastal inventory. Clickable tabs across the top of the screen provide access to physical, ecological, and ethnological information about the organism. Photos of the organism (upper left) and an interactive observed distribution map (lower left) are always visible.

The database resides on the park's computer network where it is instantly available to park employees; the database may soon be available to the general public via the internet. In the meantime, a complete version (made smaller by slightly degrading ground photo resolution) fits on a single DVD for distribution outside the park. The mapping protocols were developed for application to relatively protected and complex marine shorelines typified within Glacier Bay proper. Approximately 300 km of unmapped shoreline remains on the park's remote and exposed outer coast, and we hope to acquire compatible resource information (albeit at lower resolution) in the near future, most likely using an aerial videography approach.

Management Implications

Modern resource protection entails providing information necessary for informed decision-making, and it should also include public outreach and education. Providing a broad spectrum of relevant resource information to a wide variety of potential users, therefore, is a very legitimate management goal. Thus having a solid base of coastal resource information is essential for proper resource management in Glacier Bay National Park and Preserve.

The centralized database also allows managers to access and share the information quickly and easily because it is instantly available to anyone on the park's computer network, can be quickly and widely distributed on DVD, and will one day be even more widely available via the internet. The database is intuitive in its overall design, allowing users to rapidly locate the information they want, including custom data queries.

The potential uses of the database are diverse. For example, the dataset provides a relatively coarse baseline against which large environmental changes can be detected. The data can serve to indicate productive areas for initiating detailed studies, and researchers can use them to inform sampling design. They also identify sensitive coastal resources, including particularly productive, diverse, rare, and/or vulnerable habitats. The data themselves, along with their rapid accessibility via the database, assist in effective response to disturbances (especially human-caused ones such as oil spills) by helping managers prioritize resource protection, guide restoration, and evaluate recovery. The data, especially the ethnological encyclopedia, provide information for use by schools, park interpreters, and other educational entities. Other potential management uses for the data include coordination of logistics for search and rescue operations, and evaluation of potential bow landing sites for tour vessels seeking to put passengers ashore.

Acknowledgments

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